The evaluation of enterprise value based on partial information

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ABSTRACT : *In this paper, we used financial statements as the main information to calculate the enterprise value by discounted cash flow model. For the prediction of future cash flows in DCF model, a new method based on the Markov chain is proposed to get the growth rates of future cash flows, instead of the fixed growth rate method. The superior performance of it can be illustrated in empirical analysis. And the result shows that we can improve the accuracy of the enterprise value evaluation with partial information by using the Markov chain.*

Keywords: discounted cash flow model, enterprise value assessment, Markov chain, financial statements.

I. INTRODUCTION

In the current world, facing the rapid development of economy and the keen competition of the market, how to maximize the value of the company has naturally become the strategic objective of business activities. Estimating the company value is one of the effective means to achieve the optimal goal of financial management. At present, with the development of the assets appraisal industry, it is of great significance to research the estimation of the company value in the investment decision-making, the measurement of enterprise value and the assessment of manager performance.

The enterprise value assessment originated from the assets appraisal industry, which has a development history of more than two hundred years. There are different interpretations of the word 'value' in social activities, generally we think it is a ranking or a measure of the size of assets. Nowadays, we mainly have two kinds of different value judgment standards: 1). Fair market value, which means the trading price in buying assets or debt. 2). Book value, which equals to the net asset value.

Generally speaking, the enterprise value assessment is a comprehensive assessment of the market value of companies, according to the asset condition and predictable profitability. The company should be seen as an indivisible whole and the economic environment and industry background of the company must be fully considered. For managers, investors, analysts and other operators of market activities, they can formulate the optimal management and investment strategy to create long-term profits for enterprises by using a scientific and reasonable valuation model to evaluate enterprise value.

With the improvement and development of the securities market, the possibility of gaining extra profits by speculations is gradually reducing and the corresponding risks are also increasing. The result of enterprise value assessment will have an impact on the company's future investments and its profits. Under this background, it is very important to find a reasonable and effective valuation model for enterprise value assessment.

Up to now, the enterprise value assessment has been studied extensively. Because of earlier starting, foreign researches have contained a wide range of research routes. Irving Fisher, a famous American economist, is the founder of the theory of enterprise value assessment. He first described the sources of value. Williams proposed the concept of Discounted Cash Flow (DCF) in his book 'The Theory of Investment Value' [1]. Black Scholes put forward the option pricing model. After that, economists have researched many extension methods for the enterprise value assessment. Mary's paper shows that the annual financial statement data of the same enterprise is stable, and we can effectively predict and estimate the future data based on past information [2]. Richard and Lee used DCF method to estimate the Dow-Jones industrials and found that DCF method is better than relative valuation method [3]. Imam thinks that DCF method can better reflect the value of high-tech industry and PB valuation method is more suitable for listed companies of financial sectors, because most of the assets owned by them are highly liquid assets and the book value is roughly the same as the market value [4].

For the prediction of cash flows in this paper, there are also many related studies abroad. Badr and Choi found that the factors that influence the profits and cash flows are the company's operation scale, funding level, outside competition etc., which also affect the accuracy of the prediction for cash flows [5].

It can be said that the researches on enterprise value assessment in the US-led Western developed countries have had a complete system, and there are many deep analyses. And in Chinese market, the enterprise value assessment started in the late 1980s. Although the early academic materials in this field are almost from the translation of foreign literatures, there have been many directions of thinking and research in recent decades. After studying Shenzhen A-share listed companies, Li put forward a method to improve the discounted cash flow model by option pricing model [6]. Jiang studies the financial statements of enterprises and analyzes the impact of listing on enterprise value [7]. Yan analyzed the high-tech industry, divided the life cycle of this industry into three stages, studied the value composition and inner drive of enterprise in different stages, and put forward the corresponding value assessment methods [8]. And there are many researches on the forecasting method of future cash flows, such as BP algorithm based on neural networks and cash flows forecasting model based on EWMA-VAR.

It is obviously that there are a lot of research literature about the enterprise value assessment. But the valuation method considering partial information is not complete. In fact, the company information we can get is limited in the real market. So, in this paper, the enterprise value assessment is based on the analysis of financial statements released by the company every year and the discounted cash flow method. And it is also the situation faced by most of the investors and analysts.

Based on the original discounted cash flow model, we use Markov chain to forecast cash flows to improve the accuracy of valuation. The significance of this paper is exploring a new valuation method based on partial information in practice. And the financial statements are chosen as the source of information, because they are released to the public by listed companies and easy to obtain. This new method is reasonable and applicable to the established organizations and is meaningful to the enterprise value assessment.

II. PRELIMINARIES

There are many different valuation models for enterprise value assessment, and according to the available information we can choose the method which is the best fit. Some methods are commonly used in the evaluation process, some of them should be used in special cases, and there are also cases that need to combine a variety of models.

In this paper, we get the free cash flow data of enterprises from financial statements as basic information and then use the discount cash flow model. Therefore, we introduce the DCF model in this section.

The DCF model assumes that the current price equals the sum of those expected future cash flows discounted at a constant discount rate. And we always use the weighted average cost of capital (WACC) as a discount rate for estimated future cash flows. The WACC is the average cost the company pays for capital from borrowing or selling equity.

There are two steps in DCF model, the first step is to predict the annual free cash flow (FCF) and weighted average cost of capital (WACC).

The second step is to convert the future free cash flows into the present value under the assumption that the dividend increasing rate and the capital-cost rate remain unchanged.

The calculation formula is

$$EV = \frac{FCF_1}{1+WACC} + \frac{FCF_2}{(1+WACC)^2} + \cdots + \frac{FCF_n}{(1+WACC)^n} + \frac{TV}{(1+WACC)^n} \#(2.1)$$

$$TV = \frac{FCF_{n+1}}{WACC - g} \#(2.2)$$

And EV is the value of the company;

FCF is the future free cash flow (the subscript indicates the year);

TV is the value of the last forecast year;

g is the growth rate of free cash flows.

This model is the most commonly used valuation model at present, and it is also the important theoretical basis of the valuation method in this paper.

The main advantages of DCF model are compatibility and validity. When using this method to calculate the risk discount rate, it can accurately evaluate the value of companies with high financial leverage ratio. At the same time, it is obvious that the value of the company is time-related. This method emphasizes the consideration of future value and future earnings when evaluating the value of companies, so it has high reliability and good accuracy.

The prediction of future cash flows in DCF model is derived from the historical data in companies' own financial statements. Compared with analyzing the cash dividends in DDM method, the analysis of free cash flows can better deal with the actual situation of cash dividends of listed companies.

However, the DCF method also has disadvantages. It is difficult to predict the future free cash flows, especially for the companies in growth period and companies with cyclical businesses. Furthermore, this problem will lead to inaccurate results of enterprise value assessment.

III.   THE PREDICTION OF FUTURE CASH FLOWS

In section two, we have made a brief introduction to the discounted cash flow model. As we have known, the difficulty of this method lies in the prediction of future cash flows. When using this model, we need to analyze the data of previous years' cash flows to predict the growth rate of cash flows in the next few years.

Generally, the growth rate of a company's future cash flows is regarded as a constant value. And this prediction method is called as fixed growth rate model. We take the average value of the known past growth rates as the fixed growth rate in the prediction.

Assuming that the free cash flow in the first year of forecast period is FCF_0, according to the fixed growth rate model, the free cash flows in subsequent forecast period can be calculated, and the formula is as follows:

$$FCF_n = FCF_0 \times (1 + g)^n \#(3.1)$$

And the original model can be written as

$$EV = \sum_{i=1}^{n} \frac{FCF_0(1 + g)^i}{(1 + WACC)^i} + \frac{TV}{(1 + WACC)^n} \#(3.2)$$

$$TV = \frac{FCF_0(1 + g)^i}{WACC} \#(3.3)$$

Where n is the final forecast period; g is the fixed growth rate of free cash flows.

However, we know that the growth rates are changing in fact. So, in this paper, in order to improve the flexibility and accuracy of the growth rate prediction as much as possible, the Markov chain is used for model extension.

In stochastic mathematics, we have the following definition.

Let the state space E of random process $\{X_n, n = 0,1,2, \cdots\}$ be a denumerable set, assume that $E = \{0,1,2, \cdots\}$, if $\forall n \geq 1, \forall i, j, i_k \in E, k = 0,1, \cdots n - 1$, satisfy the following equation:

$$P(X_{n+1} = j|X_n = i, X_{n-1} = i_{n-1}, \cdots, X_0 = i_0) = P(X_{n+1} = j|X_n = i) \#(3.4)$$

then we call $\{X_n, n = 0,1,2, \cdots\}$ is a Markov chain [9].

Through the analysis of financial statements, we can find that the growth rate of cash flows in this year largely affects it in the next year. For example, if a large amount of funds is invested in this year and the cash flow in that year is greatly reduced, then it is likely to receive the return on investment in the next year so the growth rate of cash flows will increase. Of course, the cash flows data in previous years will also have an impact on the future, but it can be found that the impact is very small compared with that in the current year, especially for established enterprises. Therefore, it is reasonable to regard the stochastic process of growth rates as Markov process.

We roughly divide the growth rates of cash flows into four events: $\{X_n = 1\}$ means a significant increase of cash flow in year N; $\{X_n = 2\}$ means the cash flow increases steadily in year N; $\{X_n = 3\}$ means a steady decrease of cash flow in year N; $\{X_n = 4\}$ means a significant decrease of cash flow in year N.

We can determine a transition matrix P according to the relationship among the above four events, and the specific matrix data can be obtained by analyzing the financial statements. The transition matrix that is also called the environment of Markov chain is a key factor of Markov chain, in this paper, we get it as

$$P = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \\ p_{41} & p_{42} & p_{43} & p_{44} \end{bmatrix} \#(3.5)$$

where p_{12} equals $P(X_{n+1} = 2|X_n = 1)$.

According to the theorem of Chapman Kolmogorov equation:

1. For $\forall n, m \geq 0, i, j \in E$, we have $p_{ij}^{(m+n)} = \sum_{k \in E} p_{ik}^{(m)} p_{kj}^{(n)}$;
2. $P^{(m+n)} = P^{(m)} P^{(n)}$;
3. $P^{(n)} = P \cdot P^{(n-1)}$.

Therefore, we can use the transition matrix to calculate the probability distribution of the growth rates in the following years, and then get the mathematical expectation to get the forecasting result of cash flows.

The specific methods of operation will be detailed in the next section.

IV. EMPIRICAL ANALYSIS

The example company selected in this section is China National Accord Medicines Corporation Ltd. The main data are from the company's financial statements published on the CSRC's website.

We use the financial statement data from 2002 to 2012 released by China National Accord Medicines Corporation Ltd. to predict the growth rates of cash flows after 2012, with a forecast period that is 6 years. And the predicted results will be compared with actual data. Here are the cash-flow data from 2002 to 2012.

Table 1: the cash-flow data of China National Accord Medicines Corporation Ltd from 2002 to 2012

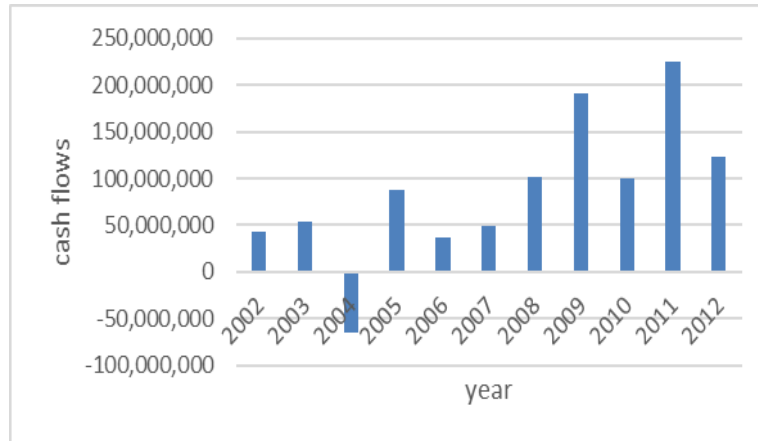| Year	2002	2003	2004	2005	2006	2007
Cash flow	42,191,078	54,350,572	-64,807,660	88,420,748	36,053,789	49,492,597
Growth rate		0.2882	-2.192	2.3643	-0.592	0.3727
Year	2008	2009	2010	2011	2012	/
Cash flow	101,860,089	191,610,628	100,125,201	224,723,366	122,863,881	/
Growth rate	1.0580	0.8811	-0.4774	1.2444	-0.4532	/

Fig 1: the cash-flow data of China National Accord Medicines Corporation Ltd from 2002 to 2012

From the table 1 and Fig 1, we can clearly see that the annual cash flows of the enterprise present a obvious trend of rising. But in 2004 there was a drop in data. As the cash flows are affected by many factors, this situation may be related to the operating decision of the enterprise in 2004, such as increasing production and expanding investment scale, which are normal.
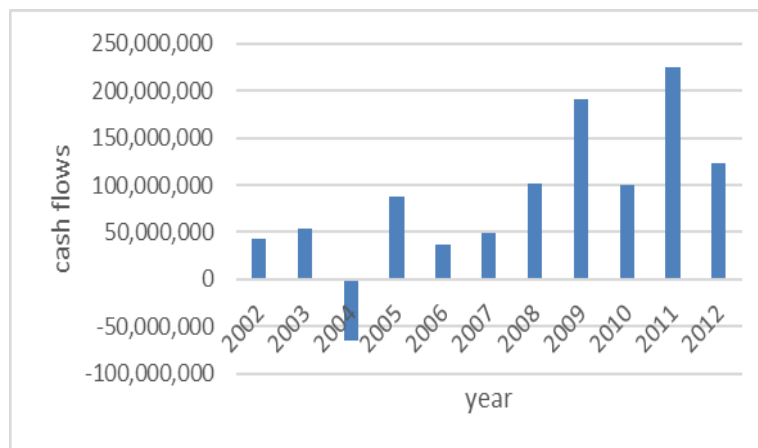

Fig 1: the cash-flow data of China National Accord Medicines Corporation Ltd from 2002 to 2012

Firstly, we use the fixed growth rate model. The average growth rate of known cash flows $g \approx 0.2993$. According to $FCF_n = FCF_0 \times (1 + g)^n$, we can get the predicted future cash-flow data.
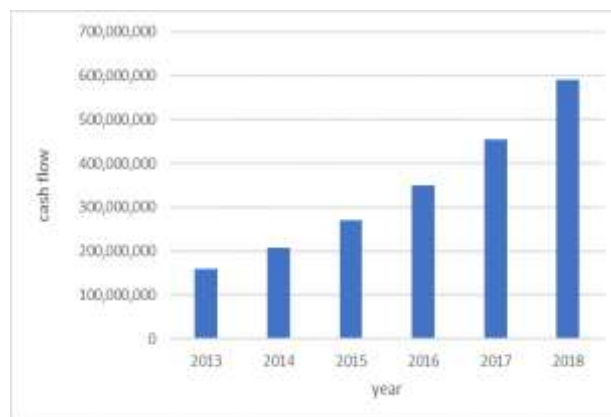

Figure 2: the future cash-flow data predicted by the fixed growth rate model

However, based on the known data and understanding, it can be seen that the free cash flows of the company sometimes change dramatically. Therefore, we need to use the forecast model based on Markov chain, which is introduced in section three, to optimize the results.

The available data of one enterprise is limited. So, we can choose several similar companies in the same industry to supplement the data. In this paper, Yunnan Baiyao, Northeast Pharm, Renhen Pharmaceutical Co. Ltd and BBCA Pharmaceutical are selected as similar enterprises, and their cash-flow data are collected and analyzed to obtain the transition matrix P.

$$P = \begin{bmatrix} 0 & 0.35 & 0.11 & 0.54 \\ 0 & 0.20 & 0.67 & 0.13 \\ 0.10 & 0.82 & 0.08 & 0 \\ 0.89 & 0.11 & 0 & 0 \end{bmatrix}$$

By researching the financial statements of China National Accord Medicines Corporation Ltd for many years, we can find that the enterprise has solid businesses., In addition, we consider that the China National Accord Medicines Corporation Ltd is a full-fledged enterprise, and cash flows will continue to increase in the future. So, we determined that when $X_n = 1,2,3,4$, the growth rate is 3.8, 1.2, - 0.4, - 3.3, respectively. In other words, $g_1 = 3.8; g_2 = 1.2; g_3 = -0.4; g_4 = -3.3$.

It is known that the growth rate from 2011 to 2012 is -0.4532, which belongs to event 3 $\{X_n = 3\}$.

Then the probability distribution of growth rate from 2012 to 2013 can be obtained according to the third row of P, and the cash flow in 2013 can be calculated, as $FCF_1 = \sum_{j=1}^{4} p_{3j} \cdot (g_j + 1) \cdot FCF_0 = 286518570$.

Naturally, we get

$$P^2 = \begin{bmatrix} 0.4026 & 0.2286 & 0.3103 & 0.0585 \\ 0.1827 & 0.6037 & 0.1876 & 0.0260 \\ 0.0080 & 0.2746 & 0.5668 & 0.1506 \\ 0 & 0.4225 & 0.1716 & 0.4059 \end{bmatrix}$$

where p_{31} means $P(X_{n+2} = 1|X_n = 3) = 0.008$.

So, we get the probability distribution of the growth rate from 2013 to 2014. According to the above data of 2013, we calculate the cash flow of 2014 as 169395509.

And so on,

$$P^3 = \begin{bmatrix} 0.0831 & 0.4878 & 0.2223 & 0.2069 \\ 0.0419 & 0.3596 & 0.4396 & 0.1589 \\ 0.1907 & 0.5399 & 0.2302 & 0.0392 \\ 0.3784 & 0.2699 & 0.2968 & 0.0549 \end{bmatrix} \ldots\ldots$$

$$P^6 = \begin{bmatrix} 0.1480 & 0.3918 & 0.3455 & 0.1148 \\ 0.1625 & 0.4300 & 0.3157 & 0.0918 \\ 0.0972 & 0.4221 & 0.3443 & 0.1364 \\ 0.1201 & 0.4567 & 0.2873 & 0.1358 \end{bmatrix}$$

In this way, we introduce Markov chain into the discounted cash flow method, and we can get the prediction of future cash flows.
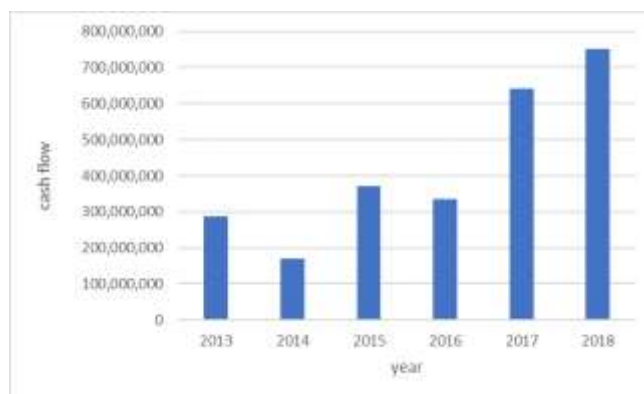
Figure 3: the future cash-flow data predicted by the Markov chain

In DCF model, we have to calculate the value of WACC for enterprise value assessment. According to the practical data of the company and market, $WACC \approx 0.0842$.

Then using equation (2.1) and (2.2), we can have the result of enterprise value assessment.
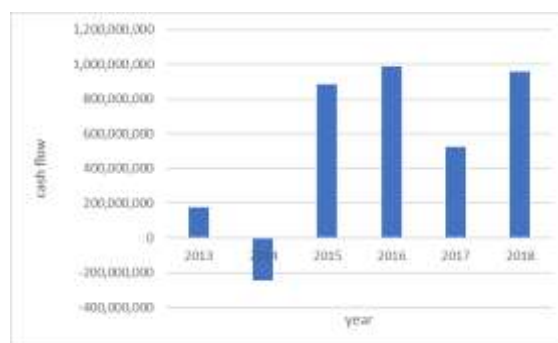

Figure 4: the actual cash-flow data from 2013 to 2018

Table 2: the comparison table of enterprise value assessment results

Method	the fixed growth rate model	the Markov chain	actual data
The result of enterprise value assessment	5,795,993,591	7,353,461,797	9,339,855,201
Error	0.3794	0.2100	/

From table 2, we can clearly find that the accuracy of enterprise value assessment has increased a lot with the future cash-flow data predicted by the Markov chain. It shows that the improvement of the original discounted cash flow model in this paper is reasonable, and the method has certain practicability. That is, based on the company's financial statements, we can use the method to estimate the value of mature companies.

Figure 5: the cash-flow data predicted by Markov chain and the actual cash-flow data

From Figure 5, we can see that the overall trend of the forecast results is consistent with the actual situation. And the deviation in prediction mainly comes from the wide fluctuations of cash-flow data in 2014 and 2015.

Considering the internal factors, the significant decrease in cash flow of business operations in 2014 is due to purchasing goods and paying for labor services. At the same time, there is a large outflow of cash flow in investment. The company's subordinate industrial enterprises continue to invest in research and development, which increases the expenditure in this period to improve innovation ability. In 2015, because of the increasing in sales and the acceleration of capital return, the net cash flow from business operations increased by 231.54\% over 2014. The capital investment in 2014 had gradually begun to get profits.

Considering the external business environment, the frequent occurrence of policies related to the pharmaceutical industry within one year indicates that 2015 is a key year for the company. It can be seen that the market environment in 2015 has a great role in promoting the development of the China National Accord Medicines Corporation Ltd.

V. CONCLUSION

The main innovation of this paper is to give an enterprise value assessment method with partial information. The original DCF model is extended by Markov chain to make the result more accurate. At present, the method of using financial statements to estimate company value is still being explored. This paper makes some new exploration.

In section 1, we summarized the principle of enterprise value assessment and some existing researches. And the DCF models used in this paper are introduced in detail in section 2. In section 3, this paper improved the original prediction method of the future cash flow of the company, and introduces the concept of Markov process to get the extended model. Then, in section 4, based on the DCF model and the predicted future cash flow, the value of the case company is estimated. We compared the estimated value with the actual value, and analyze the error causes briefly.

Of course, the inadequacy of this study is that the method used has some limitations. It is only suitable for established organizations and the estimation error is difficult to eliminate due to the change of the company's business strategy and industrial environment.

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